R & D of Straw Tube detector for High Energy Physics experiments

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Introduction

Straw tube detectors are single wire proportional counters that are widely used for large-area tracking because of low material budget. It is basically a cylinder having a carbon loaded kapton film on the inner side and an Aluminium coated Kapton on the outer side. The thickness of the straw wall is around 65 μm. We are exploring the possibility of using straw tubes for the 3^{rd} and 4^{th} stations of CBM Muon Chamber (CBM-MUCH) at FAIR where the goal is to track charged particles and identify di-muons produced from decay of low mass vector mesons [1–4]. The main challenge for the detectors in the CBM experiment will be the high particle densities, since it is designed to run at an interaction rates $\sim$ 10 MHz. Therefore it is crucial to test the rate handling capability and the effect of prolonged radiation on the detectors. Such studies have been performed and reported earlier [5–9]. In this article we are reporting the stability of performance of the straw tube detector under prolonged radiation.

Experimental set up

A straw tube prototype has been obtained from JINR, Dubna, Russia with 6 straws of diameter 6 mm and length 25 cm. There is a provision to collect signals from the straws through LEMO output. A premixed gas of Argon and CO_2 in 80/20 volume ratio has been used in flow mode at a rate of 3 lt/h. The positive high voltage (HV) is applied to one end of the central wire of the straws using a HV filter box and the signal is collected from the other end through a capacitor. The output signal from the straw is fed to a charge sensitive pre-amplifier and the output of the pre-amplifier is put to a Multi Channel Analyser (MCA) for obtaining energy spectra of the detector. The straw tube detector has a typical gain of 1.4 $\times$ 10^4 at a biasing voltage of 1550 V. In order to study the effect of prolonged radiation on the detector, the collimated source is placed on top of the detector and continuous monitoring of the energy spectra with the same source is been carried out. We have set a particle rate of 40 kHz/mm using the collimator. ORTEC MCA has been used to store the spectra automatically at a regular interval of time. A data logger made in house has been used to record ambient temperature and pressure online using CuteCom software package.

Results

The gain and T/P as function of time is shown in Fig 1. The measured gain is normalised by the theoretically obtained gain $G(T/p) = Ae^{BT/p}$.

The factors A and B are obtained by fitting the gain vs. T/p correlation plot with the above mentioned function. The normalised gain is shown in the figure as a function of accumulated charge. The accumulated charge has been calculated using the relation,

$$\frac{dq}{dl} = \frac{r \times n \times e \times G \times dt}{dl} \quad (1)$$

where r is the measured rate (in Hz) incident on a particular area of the detector, n is the

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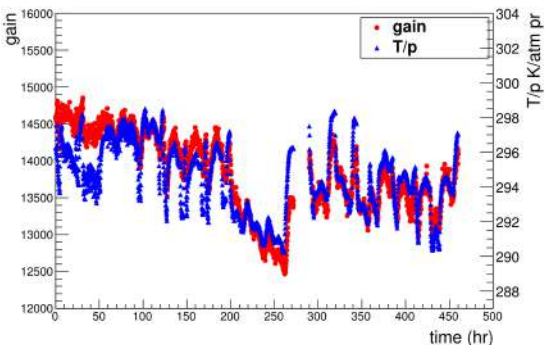

FIG. 1: Gain and T/p vs. time

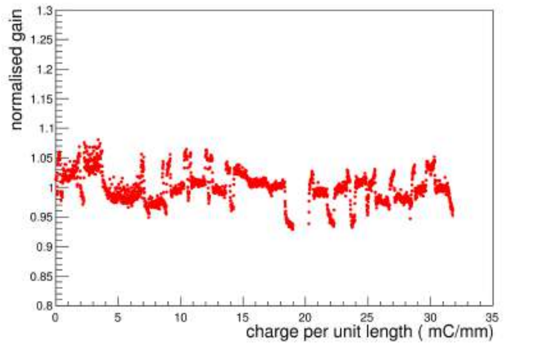

FIG. 2: Normalised gain vs. charge per unit length

number of primary electrons for a single X-ray photon, e is the electronic charge, G is the gain of the detector, dt is the time in second and *dl* is the irradiated length of the straw. The mean normalised gain has been found to be 0.99 with a rms of 0.021 for a continuous operation of 450 hours, which is equivalent to an accumulated charge per unit length of 32 mC/mm. No deterioration in gain of the detector has been observed.

Summary

R & D is carried out with one small straw tube detector prototype. The main motivation of this work is to study the effect of prolonged radiation on the straw tube detector. The gain and energy resolution of the detector is studied with premixed gas of Ar/CO_2 80/20. No degradation in the performance of the straw tube detector after accumulation of 32mC/mm of charge is observed.

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